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Briefing Report to the Chairman, Subcommittee on Defense, Committee on Appropriations, House of Representatives

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ARMY WEAPONS

Status of the Sense and Destroy Armor System

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United States
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National Security and
International Affairs Division

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December 17, 1990

The Honorable John P. Murtha
Chairman, Subcommittee on Defense
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

The Army's Sense and Destroy Armor (SADARM), a new system of target-sensing munitions, is being developed to enhance the capabilities of the 155-millimeter (mm) howitzer and the Multiple Launch Rocket System (MLRS) to attack targets such as self-propelled enemy artillery, when stationary. Through fiscal year 1991, the Congress has provided about $600 million in research, development, test, and evaluation funding for the system.

In 1988, we reported on the status of the SADARM system.[1] As you requested, we have updated that analysis to determine (1) actions taken by the Army to comply with congressional directives, (2) the current program schedule, (3) the Army's estimate of the program's total cost, (4) the status of technical development, (5) test results to date, and (6) the Army's assessment of the counterfire mission and of SADARM's ability to meet that requirement.[2]

In March 1990, we briefed your staff on the preliminary results of our review for use during hearings on the fiscal year 1991 defense budget. In October 1990, we briefed your staff on the final results of our review. This report summarizes the information provided at the October briefing.

Results in Brief

Our review disclosed the following:

- The Army has restructured the SADARM development program to address congressional concerns about development deadlines and technical risks.
- The program is over 3 years behind its original schedule and the full-rate production decision is now scheduled for July 1994.
- The Army now estimates the total cost of the program to be about $4.7 billion. Increased development costs are expected to be more than

[1] DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-88-160, June 30, 1988).

[2] "Counterfire" is fire intended to respond to enemy indirect fire systems.

offset by the decision to substantially reduce the number of SADARM munitions to be bought.

- SADARM's technical development is in its final stages of component design testing.
- SADARM's application to the 155-mm howitzer and the MLRS have not yet been tested, but its application to the 8-inch howitzer was successfully tested, according to Army officials.
- The Army's February 1990 threat assessment reaffirmed the importance of SADARM and its counterfire capability.

Appendix I provides more detailed information on the results of our review.

SADARM Development Program Restructured

The Army's March 1990 revised SADARM development program calls for the concurrent development of SADARM for the 155-mm howitzer and the MLRS, the completion of developmental testing before a design is selected, and competition among potential contractors into production.

Program Schedule Has Slipped and Costs Increased

Congressional directives, budgetary pressures, and other problems have extended the SADARM development schedule. Between September 1986 and March 1990, the original schedule was extended by over 3 years. The revised schedule calls for making full-rate production decisions in July 1994 instead of September 1990 for the MLRS SADARM and June 1991 for the 155-mm SADARM as originally scheduled. In addition, the revised schedule calls for fielding the 155-mm SADARM in July 1994 and the MLRS SADARM in December 1995 instead of the original targets of December 1991 for the 155-mm SADARM and February 1991 for the MLRS SADARM.

Since 1986, the estimated cost of the program has decreased by about $634 million to about $4.7 billion. While development costs increased by $542 million, procurement costs decreased by about $1.2 billion because the Army substantially reduced the number of SADARM munitions it planned to buy. This quantity reduction has resulted in an increase in unit costs.

Technical Development and Testing

The technical development of SADARM is in the final stages of component design testing for the munitions, the 155-mm projectile, and the MLRS rocket dispenser.

Because SADARM is still being designed and tested, its capabilities with the 155-mm howitzer and the MLRS have not been fully determined. However, as required by a congressional directive, the Army conducted tests of SADARM using the 8-inch howitzer and concluded that they were successful.

Ability to Meet Counterfire Mission

The Army updated its threat assessment as of February 1990 and reaffirmed the importance of SADARM and its counterfire capability. Army representatives said that the Army had reduced the planned procurement quantity for SADARM because of the reduced European threat. However, recent and continuing developments in Europe, the Soviet Union, and the Middle East are greatly altering the national security environment, and these events could significantly affect the requirements for SADARM.

Scope and Methodology

We updated our analysis of the SADARM program by assessing relevant program documents such as the operational requirements document, selected acquisition reports, program cost estimates, acquisition and test plans, monthly program status reports, briefing documents, and quarterly program reviews from contractors. We obtained information from and interviewed officials at the Office of the Project Manager for Sense and Destroy Armor and the Fire Support Armaments Center, Picatinny Arsenal, New Jersey, and Army Headquarters, Washington, D.C. We conducted our review from September 1989 to August 1990 in accordance with generally accepted government auditing standards.

As requested, we did not obtain official agency comments on this report. However, we discussed its contents with Department of Defense and Army officials and have incorporated their comments where appropriate.

We are sending copies of this report to the Chairmen of the Senate and House Committees on Armed Services, the House Committee on Government Operations, and the Senate Committees on Appropriations and on Governmental Affairs. Copies are also being sent to the Secretaries of Defense and the Army, the Director of the Office of Management and

Budget, and other interested parties. Copies will be made available to others on request.

Please contact me on (202) 275-4141 if you or your staff have any questions concerning the report. The major contributors were Henry Hinton, Associate Director, Army Issues; Raymond Dunham, Assistant Director, Army Issues; and Manfred J. Schweiger, Senior Evaluator-in-Charge, New York Regional Office.

Sincerely yours,

Richard Davis

Richard Davis
Director, Army Issues

Status of the SADARM System

Background

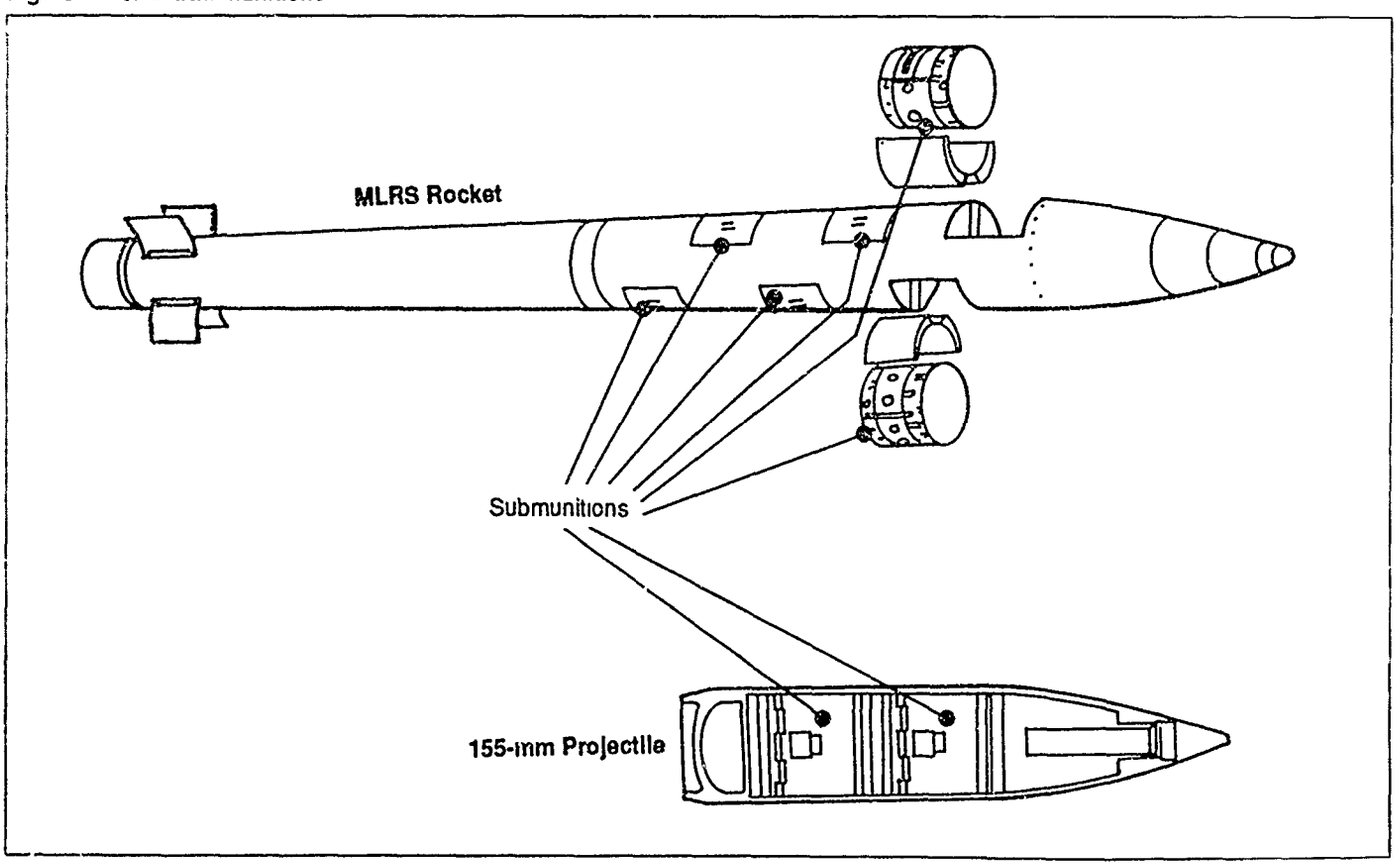
The SADARM is a "fire-and-forget" system designed to defeat targets such as self-propelled artillery, infantry fighting vehicles, and other lightly armored combat vehicles, when stationary. The munition is being developed for two existing weapon systems—the 155-millimeter (mm) howitzer and the Multiple Launch Rocket System (MLRS).

Operating the SADARM System

SADARM is designed in two sizes, both cylindrically shaped submunitions: (1) the 5.8-inch submunition, together with a thin-walled base ejection carrier (projectile), is used with 155-mm howitzers, and (2) the 6.9-inch submunition, together with a warhead dispenser mated to an existing rocket motor, is used with the MLRS.

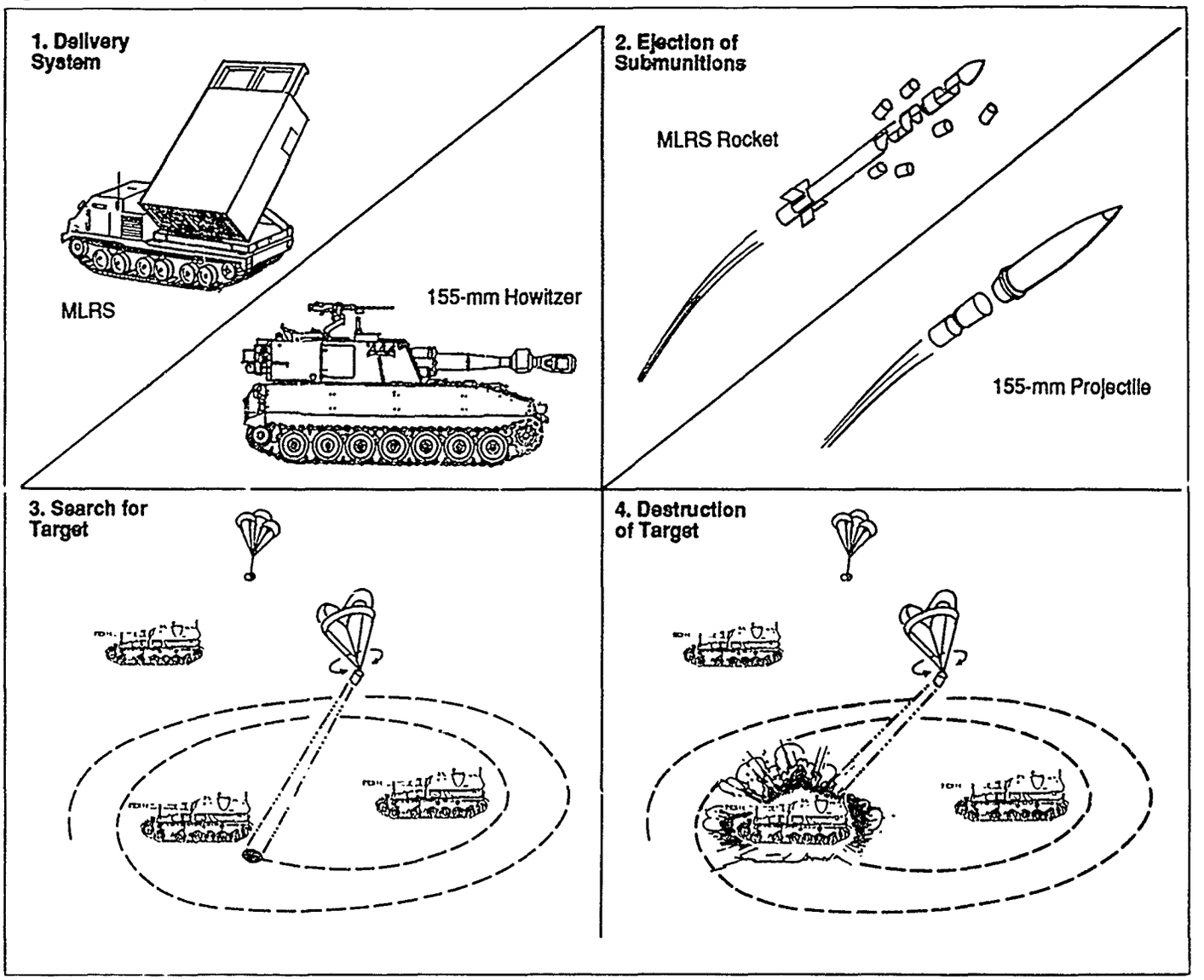
The 155-mm projectile carries two submunitions, and the MLRS rocket dispenser carries six. Each submunition has the capability to sense and defeat a target. The SADARM munitions are shown in figure I.1.

Figure I.1: SADARM Munitions



The submunitions are ejected from the 155-mm projectile or the MLRS rocket over the target area. Upon ejection, each submunition first deploys a "deceleration and despin device" that slows its speed and its spinning, followed by an "orientation and stabilization device" that activates the power supply, drops its velocity, and sets a fixed rotation speed to enable the sensors to scan the target area. A "range-sensing device" on the descending SADARM detects the preset ground slant range and arms the lethal mechanism, and the sensor begins its ground search pattern. The spiral search pattern decreases in area and travels toward the center as the descent continues. If the millimeter wave and/or infrared sensors detect a target in the search area, they send an impulse to the lethal mechanism, which fires an explosively formed penetrator down into the target. If no target is detected, the submunition self-destructs just before hitting the ground. The operational concept for SADARM is shown in figure I.2.

Figure I.2: SADARM Operational Concept



Program History

Originally, the Army intended to develop SADARM as an anti-armor munition to provide 8-inch artillery with the ability to detect and defeat tanks and other mobile, hardened, armored targets. In 1980, the Army awarded competitive advanced development contracts to Alliant Techsystems, Inc.,[1] and Aerojet Electro Systems Corporation for the 8-inch

[1]Until recently, Alliant Techsystems, Inc., was called Honeywell, Inc.

projectile and the 6.9-inch submunition. However, in 1984, the Army terminated that effort because of SADARM's limited capability against moving targets. Subsequently, in 1985, the Army reinstated the SADARM development as a counter-battery weapon for primary use against stationary self-propelled howitzers and secondary use against lightly armored vehicles. The Army approved its requirements document for developing SADARM for the 155-mm howitzer and the MLRS in March 1986.

In September 1986, the Army approved full-scale development of the SADARM submunitions and awarded 48-month cost-plus-incentive-fee contracts to Alliant Techsystems, Inc., and Aerojet Electro Systems Corporation to develop the two sizes of submunitions and the 155-mm projectile. The Army also awarded an initial integration contract for the MLRS rocket dispenser to LTV Aerospace Defense Company in December 1986. Shortly after the Army awarded these contracts, the Department of Defense (DOD) designated SADARM as a major program because of its cost and congressional interest. With this designation, the SADARM program was required to undergo more stringent reviews by the Army and DOD at various stages in its development.

DOD reinstated SADARM's application to the 8-inch howitzer in November 1986. However, in August 1987, the Army again terminated those efforts because it intended to eliminate the 8-inch howitzer from its inventory. Additionally, it decided to develop only the 5.8-inch submunition for both the 155-mm howitzer and the MLRS. In May 1988, after a DOD review, the Secretary of Defense approved SADARM's full-scale development for the 155-mm howitzer and the MLRS and directed the Army to develop two sizes of submunitions to maximize lethality against the full spectrum of armored targets. He also directed the Army to study alternatives for the 8-inch howitzer.

In June 1988, the Army told DOD that it planned to phase out the 8-inch howitzer, starting in fiscal year 1990, and to replace it with the MLRS. The Army completed the SADARM program structure by awarding the full-scale MLRS rocket dispenser development and integration contract to LTV in September 1988—1 year later than originally planned.

The Army Has Complied With Congressional Directives

In response to congressional directives, the Army revised its original program structure and schedule in July 1987. The original schedule, set in September 1986 with the award of the 48-month full-scale development contracts, had called for deferring the bulk of work on the 155-mm projectile until June 1987. After conducting a technical and design competition between the two contractors, the Army had planned to select one submunition design 30 months into the development effort.

Congressional Directives

The Conference Committee reports on DOD appropriations for fiscal years 1986 and 1987 directed the Army to restructure the SADARM program. The conferees were concerned that technical and financial decisions were being driven by artificially short deadlines rather than by specific technical accomplishments and efforts to reduce program risks. The directives required (1) at least a 60-month full-scale development program; (2) concurrent development of the MLRS and 155-mm submunitions; (3) an early firing demonstration of an 8-inch howitzer using modified hardware from the advanced development phase; (4) approval by the Senate and House Committees on Appropriations before release of funds for the final phase of engineering development, system qualification, and developmental and operational testing; and (5) support of at least two competing prime contractors throughout development and into production.

The Restructured Program

The Army's restructured SADARM acquisition program, approved in July 1987, provided for a 67-month development effort. Specifically, (1) the two development contracts were amended from 48 months to 60 months, and (2) development of the two submunitions was to start simultaneously and run concurrently.

The Army also revised the SADARM test and evaluation program to address congressional concerns about the need for more testing and adequate proof of principle, that is, the need to demonstrate SADARM's capabilities and thereby reduce program risks. The revised program provided for demonstration tests using modified 8-inch howitzer hardware that had been used during advanced development. Before completing those tests in July 1989, the Army told the Committees on Appropriations that the tests had delayed the development schedule for the 155-mm and MLRS applications. To avoid further slippage of the schedule, the Army requested relief from the congressional restriction on obligating funds for development and operational test hardware. The restriction was removed in July 1989.

The revised SADARM test program also expanded live-fire testing, increased test quantities and the target requirement, and added test instrumentation and funding for risk assessment. In addition, the test schedule provided for completing submunitions and projectile operational testing before design selection, projectile type classification,[2] and the decision to go ahead with full-scale production. Operational testing of the MLRS rocket dispenser was scheduled after the MLRS SADARM rocket was to have been approved for limited production; however, the testing was to precede the MLRS type classification and the award of the contract for full-scale production.

The Army's implementation of the congressional directives commits it to maintaining competition by carrying the two current development contractors into competitive production. An alternative acquisition strategy under consideration would carry two designs into production provided both contractors have acceptable designs.

Program Is Behind Original Schedule

The SADARM program is over 3 years behind its original schedule. The Army's March 1990 revised schedule calls for making full-rate production decisions in July 1994 instead of the original targets of September 1990 for the MLRS SADARM and June 1991 for the 155-mm SADARM. In addition, the March 1990 schedule calls for fielding the 155-mm SADARM in July 1994 and the MLRS SADARM in December 1995 instead of the original targets of December 1991 and February 1991.

The schedule was revised in July 1987 when the Army implemented the congressional directive and reinstated the 8-inch howitzer SADARM application. It was revised again in September 1988 when the Army awarded a 60-month full-scale development contract for the MLRS dispenser. In March 1990, the schedule was updated a third time to reflect the impacts of technical difficulties, budgetary shortfalls, and an extensive government testing schedule. Table I.1 shows the changes in the SADARM program schedule.

[2]Type classification identifies items that are acceptable for their intended missions and for introduction into the inventory. Army policy requires items to be type classified before they are procured.

Table I.1: Changes in the SADARM Program Schedule

Milestone	Sept. 1986 original schedule	July 1987 revised schedule	Sept. 1988 revised schedule	Mar. 1990 revised schedule
		Submunitions and projectile		
Contract award	Sept 1986	Sept. 1986	Sept. 1986	Sept. 1986
Operational testing completed	Mar. 1991	May 1991	Dec 1991	Sept. 1993
Low-rate initial production decision	May 1989	Sept. 1989	[a]	Apr. 1993
Full-rate production decision	June 1991	June 1991	Apr. 1992	July 1994
First unit equipped with 155-mm SADARM	Dec. 1991	Mar. 1993	July 1993	July 1994
		MLRS dispenser		
Contract award	May 1987	Sept. 1987	Sept 1988	Sept 1988
Operational testing completed	Sept 1990	Mar. 1992	July 1993	Mar 1994
Low-rate initial production decision	Oct. 1988	May 1989	Jan 1992	[a]
Full-rate production decision	Sept. 1990	Mar 1992	Sept 1993	July 1994
First unit equipped with MLRS SADARM	Feb. 1991	Mar. 1993	May 1994	Dec 1995

[a]The Army's schedule did not include low-rate initial production decisions

Program Cost Estimate Has Decreased, but Unit Costs Have Increased

The Army's estimated total program cost for SADARM has decreased by $634 million from the original September 1986 estimate of about $5.3 billion. This is a net figure consisting of a $542 million increase in development costs and about a $1.2 billion decrease in procurement costs. Development costs have increased because of congressional and DOD program requirements and higher-than-anticipated contractor development costs. Procurement costs have decreased because the Army substantially reduced the number of SADARM munitions it planned to buy. According to Army officials, the procurement quantity was reduced because of the changing threat in Europe. This reduction in the planned procurement quantity has resulted in an increase in SADARM's unit cost.

The Army's estimated cost of the program has changed several times since 1986. In September 1986, the Army estimated the program cost at approximately $5.3 billion for the planned acquisition of 600,000 submunitions. This cost increased to about $5.7 billion for 484,296 submunitions in July 1987, and then increased to about $6.2 billion for the same number of submunitions in December 1988. However, in May 1990, the estimated cost decreased to approximately $4.6 billion because the Army decided to acquire 222,756 submunitions rather than the previously planned 484,296. (See table I.2.)

Table I.2: Changes in the SADARM Program's Cost Estimate

Dollars in millions

Item	Sept. 1986 estimate	July 1987 estimate	Dec. 1988 estimate[a]	May 1990 estimate[b]
Research and development	$365.1	$589.7	$702.9	$906.9
Procurement	4,933.0	5,104.6	5,495.3	3,757.0
Total	**$5,298.1**	**$5,694.3**	**$6,198.2**	**$4,663.9**

[a]In December 1988, the Army prepared cost estimates for the September 1988 revised program schedule.

[b]In May 1990, the Army prepared cost estimates for the March 1990 revised program schedule

As shown in table I.3, the Army has reduced the number of SADARM munitions it plans to acquire, which has resulted in an increase in the estimated unit costs.

Table I.3: Changes in SADARM Acquisition Quantities and Unit Costs

Item	Sept. 1986 estimate	July 1987 estimate	Dec. 1988 estimate	May 1990 estimate
			Acquisition quantities[a]	
MLRS warheads	50,000	59,174	59,110	23,712
155-mm projectiles	150,000	63,530	63,385	39,018
			Unit cost	
MLRS warheads	$40,608[b]	$44,380	$59,981	$82,384
155-mm projectiles	11,307[c]	11,420	13,609	19,453

[a]This is the total number of MLRS warheads and 155-mm projectiles being procured with SADARM munitions

[b]The unit cost is based on the low-rate initial production quantity of 82,392 submunitions, which equates to 13,732 MLRS SADARM rockets The unit cost estimate does not include the cost for the warhead/dispenser

[c]The unit cost is based on the low-rate initial production quantity of 15,125 projectiles

Technical Development Is in Final Design Testing Stages

SADARM's technical development is in the final stages of design/testing for the submunition components, the 155-mm projectile, and the MLRS dispenser. Through May 1990, the two submunitions and projectile contractors conducted an extensive series of development tests, including tests of the subsystems. Under the March 1990 program schedule, the contractors for the submunitions and projectile are scheduled to complete design and qualification tests by October 1991, and government tests are scheduled to be conducted between July 1991 and September 1993.

The contractor's development testing of the MLRS dispenser has been less extensive because only the SADARM dispenser section is new to the MLRS

rocket. Under the March 1990 schedule, development, design, and qualification of the dispenser will end in March 1991, and government tests are scheduled to be conducted between October 1991 and March 1994.

Submunition Component Testing

Development testing of the submunitions and projectiles involves three major submunition components: the deceleration system, the sensor, and the lethal mechanism.

Deceleration System

The two-stage deceleration system slows the submunition down and stabilizes it after it has been expelled from the carrier. This system has undergone several types of tests: wind tunnel, whirl tower, cable drop, rocket sled, ballistics ejection, gun-firing, and rocket flight. Both contractors have essentially completed their designs; however, more gun-firing and ballistics ejection tests must be completed to verify the functional operation of the final designs.

Sensor

Upon activation, the dual-mode (millimeter wave and infrared) sensor begins a ground search to detect targets for destruction. The sensor has been extensively tested in five major captive flight test programs; in drop, laboratory, radiation, and rail gun tests; and in live-fire data collections.[3] The flight tests were conducted to accumulate sufficient background and target signature data to design and develop the final tactical sensor signal processing procedures. More than 64,000 target engagements in various climatic and geographical environments, and against the complete spectrum of countermeasures, have been conducted to evaluate the performance of the sensor. The two contractors' sensor designs are nearing completion; however, the contractors must conduct additional captive flight and helicopter drop tests to complete and verify their final tactical sensor processing procedures before the government evaluation.

Lethal Mechanism

Upon detection of the target, the lethal mechanism fires an explosively formed penetrator into the top of the target. The mechanism has been subjected to a series of short- and maximum-range horizontal test firings and live-fire tests. The two contractors have fired more than 180 lethal mechanisms, and both contractors' MLRS and 155-mm designs have met the specified target perforation requirement.

[3]In the "captive flight tests" the sensors were mounted in helicopters, which flew over targets to determine whether the sensors could detect targets.

One contractor's designs are virtually completed; designs for the two lethal mechanisms have been selected, and verification tests have been completed. Additional tests were to be completed and a final design qualification test was to be conducted to complete the design effort. The other contractor must complete testing to baseline its two designs and must conduct verification and qualification tests of its final designs before the government evaluation.

155-mm Thin-Wall Projectile Testing

The 155-mm thin-wall projectile, when fired from a howitzer, delivers the SADARM submunition to, and ejects it over, the target area. The projectile has been evaluated in low-elevation and vertical gun firings, as well as in static and dynamic ejection, drop, and other tests. Both contractors have developed acceptable projectile designs, according to the Army. One has completed its projectile development testing, and the other has to select one of two designs as its final design. The two contractors are required to demonstrate projectile capability in live firings.

MLRS Warhead/Dispenser Testing

The MLRS warhead/dispenser, which serves the same purpose as the 155-mm thin-wall projectile, has essentially completed its design and development test phase. Development testing involves three components: the fuze, the initiation transfer system, and the dispense mechanism. All these components have been, or are being, fabricated and delivered for the MLRS flight tests.

Fuze

The MLRS fuze, an existing fuze modified to meet SADARM's requirement, has completed development and qualification testing. The fuze's Critical Design Review was conducted in December 1989, and its Government Safety Board Review was completed in February 1990.

Initiation Transfer System

The initiation transfer system, which starts and times the SADARM submunition ejection sequence for the MLRS, has completed its development testing. The system's Critical Design Review was held in October 1990. Qualification testing was completed by one contractor in August 1990 and is in process for the other contractor.

Dispense Mechanism

The dispense mechanism, which ejects the six SADARM submunitions from the MLRS warhead, has completed development testing. The dispenser's Critical Design Review was held in September 1988, and the design was updated in March 1990. Qualification testing, which is in process, is expected to be completed in March 1991.

Government Tests

Government submunition and projectile testing is scheduled to start in July 1991 with the live firing of seventy-eight 155-mm projectiles. This development demonstration test will proceed through a series of technical tests ending in October 1992, which involve 858 projectile firings to verify that the 155-mm projectile meets performance, reliability, and safety requirements. These tests will form the basis for a planned April 1993 low-rate initial production decision for the projectile. Government tests, consisting of a 72-projectile live-fire initial operational test and evaluation, are scheduled to be completed in September 1993.

Government testing of the MLRS-SADARM warhead is to begin in October 1991 with a performance test involving seven rocket flights per contractor. This is to be followed by technical tests, involving 18 rocket flights per contractor, to verify system performance and ground testing, involving 16 warheads per contractor, to evaluate safety and other issues. Government testing is scheduled to end in March 1994 with a combined preproduction qualification test and initial operational test and evaluation. This testing will involve 28 MLRS rocket flights and 126 submunition firings to evaluate the dispenser's operational effectiveness and the submunition's performance.

Contractor Tests to Date Have Been Successful, According to the Army

Because SADARM's application to the 155-mm howitzer and the MLRS is still in the design/testing stage, its capabilities in those applications have not been demonstrated. However, in accordance with the 1986 congressional directive, SADARM's application to the 8-inch howitzer was tested and, according to Army officials, proved successful.

The 8-inch howitzer demonstration testing started in January 1989 and was completed in July 1989. At the final test, Aerojet fired four projectiles with one submunition each. The major components of three submunitions (deceleration system, sensor, and lethal mechanism) functioned correctly, and two targets were penetrated. The fourth submunition lost its deceleration device. Alliant Techsystems, at the final test, fired two projectiles, each with one live submunition. The major components of one submunition functioned correctly but failed to locate a target. The second submunition tangled in its parachute and self-destructed on the ground.

The Army believes that this testing was successful and that both contractors demonstrated improved reliability of the subsystem. According

to project officials, the goal of the test was achieved; the test reconfirmed the system's proof of principle and reduced risk to the full-scale development program.

SADARM's Counterfire Mission Continues to Receive High Priority

The Army continues to highly rate the importance of the counterfire mission and has given SADARM a high priority, as indicated by its budget request in fiscal year 1991 and the Five-Year Defense Plan.

During its 1985 assessments of artillery fire support systems, the Army found that the primary deficiency in artillery fire support was insufficient lethality. The Fire Support Mission Area Analysis Update for Battlefield Development Plan, 1985, and other studies concluded that current field artillery systems were limited in accuracy, lethality, and volume of fire and that the required volume of fire to destroy enemy targets was inordinately high and, in most cases, impractical. The assessment also considered the important role that massed threat artillery, deployed at a large numerical superiority, would play in a Soviet main ground attack. With the fielding of fully armored, self-propelled artillery, this threat has become less vulnerable to conventional counterfire. The Army concluded that SADARM munitions, with their target-sensing capability, were needed as a force multiplier to reduce the field artillery's dependence on firing a high volume of conventional munitions—such as 155-mm M483 projectiles and MLRS dual-purpose (anti-personnel and anti-materiel) munitions—to destroy targets.[4] It also concluded that SADARM's target-sensing capability would help to reduce the fire support needed to defeat armored, self-propelled artillery supporting the main ground attack.

The Army updated its SADARM system threat assessment as of February 1990, and the update reaffirmed the need for SADARM. According to Army representatives, the Army reduced the planned procurement quantity because of the reduced European threat. However, recent and continuing developments in Europe, the Soviet Union, and the Middle East are greatly altering the national security environment, and these events could significantly affect the requirements for SADARM.

[4]SADARM is considered a "force multiplier" because fewer munitions would be needed to defeat the same number of targets.